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~~METHOD FOR PRODUCING A CERAMIC BODY HAVING AN~~ INTEGRATED ~~PASSIVE~~ ELECTRONIC MODULE, SUCH A BODY AND ~~USE OF~~ SAME

The invention relates to a method for producing a ceramic body having a monolithic multilayer structure. At least one passive electronic module is integrated into the volume of the body. Moreover, such a body is presented and an utilization of the body is given.

The highest possible miniaturization is desired in the electronics. This is particularly the case with respect to the mobile radio telephone technology. It is desired to unite as many electronic modules as possible in an optimally small space. Such components can be highly complex high-frequency modules up to complete radio parts, for example.

Substrates in the form of ceramic bodies having a monolithic multilayer structure have proven to be advantageous with regard to the miniaturization. On the basis of specific manufacturing methods, it is possible to integrate a passive component such as an inductance, a capacitor or a resistance into the volume of a ceramic body. Nowadays, a series of products is manufactured in this way. For example, ceramic multi-chip modules (MCM-C), simple high-frequency components such as LC filters and RLC networks belong thereto.

A specific method for producing a ceramic body having a monolithic multilayer structure is based on the LTCC ("low temperature cofired ceramic") technology (see D.L. Wilcox et al., Proc. 1997 ISHM Philadelphia, page 17 - 23, for example).

The essential method steps of this technology are:

- producing a ceramic green film containing an organic binder

- generating an opening in the green film, which is meant for an electronic through-connection through the green film
- filling the opening with electrically conducting material
- printing upon the green film with an electrical conductor structure
- stacking and laminating this green film and at least one further one to form a composite
- debinding and sintering the composite to a body having a monolithic multilayer structure.

Glass ceramic having a low sintering temperature thereby serves as ceramic material. The surface of a ceramic body received in the described way is fashioned such that active components, such as SMD components or ~~Ics~~ ICs (semiconductor components), can be arranged in an optimally space-saving fashion. The flip-chip technology becomes increasingly important for attaching the active components. Highest precision and reproducibility of the conductor and pad structures on the surface of the body represent a condition for the application of this technology. A component tolerance of ± 0.1 % is necessary with respect to a high process safety of this technology and a high quality of a component produced therewith.

In the traditional LTCC technology, a lateral shrinkage of 15 - 18 % with a tolerance of ± 0.5 % occurs as a result of the compressing of the ceramic material during the sintering process. If this technology or a similar method is used in the known way for producing a ceramic body, the body would be only suitable for the further processing in the flip-chip technology in a limited fashion. In order to keep the component tolerance of ± 0.1 % required for this technology, the lateral shrinkage of the ceramic material must be suppressed during the sintering process. This means that a directed compressing of the ceramic must be forced perpendicular to the film planes (= zero xy shrinkage).

There are various possibilities for suppressing the lateral shrinkage of a laminated and debinded stack composed of ceramic green film during the sintering. For example, a

high one-axle pressure is exerted onto the film stack during the sintering. However, this requires a relatively high technical outlay.

A method, which is significantly more elegant compared thereto, is to stack the green films such that the uppermost film and the lowermost film have a ceramic material, whose sintering temperature is above the one of the ceramic material of the films lying in between the stack. The sintering ensues such that the ceramic material of the inner films, which sinters given a lower temperature, becomes compacted. The non-compacting material prevents the lateral shrinkage of the film stack in that the laminated films adhere to one another. The non-compacted ceramic material of the body is removed after the sintering. In additional working steps, metallizations must be subsequently attached to the surface of the body for purposes of further processing (e.g. flip-chip technology).

JP 06 09 76 56 A discloses a similar method. The green films ~~film~~ are ~~[sic]~~ stacked such that the outer green films comprise a ceramic material whose sintering temperature is below the one of the ceramic material of the inner green films situated in the stack between the outer green films. A two-stage sintering process is carried out, whereby only the ceramic material of the outer green films becomes compacted at a first low sintering temperature and whereby only the ceramic material of the inner green films becomes compacted at a second higher temperature.

United States Patent A-5 102 720 also discloses a method for producing a monolithic multilayer body. Glass layers, which can comprise a low portion of ceramic material, and ceramic green films, which can comprise a low portion of glass, are alternately arranged on top of one another to form a stack. The stack is sintered in a single-stage sintering process, namely only at one sintering temperature, whereby the lateral shrinkage is mainly suppressed by interdiffusion particularly of glass between the layers. A multilayer body is obtained, whereby layers high in ceramic and layers high

in glass alternate. However, an exact adjustment of a physical property of a layer, for example the permeability of the layer, is difficult.

United States Patent A-5 769 987 discloses a method for producing a ceramic body in the form of a monolithic multilayer body, whereby ~~whereby [sic]~~ two pre-sintered, ceramic, possibly multilayered components are connected to one another with the aid of a connecting layer composed of glass or glass ceramic. The ceramic material of the pre-sintered components has already become compacted. The monolithic multilayer body arises by sintering the composite from the components and the intermediately situated glass ceramic layer, whereby the lateral shrinkage of the glass ceramic is suppressed.

In order to obtain an optimally high miniaturization, it is desired when all essential functions of the components are integrated into the body acting as substrate. For example, this can relate to identical components, which, however, respectively fulfil an opposite specification. A very high and very low inductance are to be simultaneously contained in one single substrate, for example. A traditional ceramic body fulfils such wishes only to an extremely limited extent.

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SUMMARY OF THE INVENTION

The invention is based on the object of proposing a method for producing a ceramic body in LTCC technology, which has a monolithic multilayer structure and which has a very slight lateral tolerance.

This object is achieved by a method for producing a ceramic body comprising a monolithic multilayer structure and at least one passive electronic module, comprising the following method steps:

- producing a green film containing a binder,
- stacking at least one green film to form a stack, which green film comprises a ceramic material composed of glass ceramic that becomes compacted at a first temperature interval, and at least one green film, which has a ceramic material that

becomes compacted at a temperature interval that is different from the first temperature interval,

- laminating the stack to form ~~a~~ composite,
- debinding the composite at an increased temperature,
- sintering the composite at a temperature of the first temperature interval until the ceramic material, which becomes compacted in this temperature interval, is mostly compacted, and
- sintering the composite at a temperature of the time interval that is different from the first time interval until the ceramic material, which becomes compacted in the temperature interval that is different from the fist temperature interval, is mostly compacted.

A ceramic body having a monolithic multilayer structure is characterized in that the ceramic layers of the body are firmly connected to one another and form a unit. Individual layers can thereby also be composed of a non-ceramic material (e.g. metal). In order to receive a monolithic body, a stack composed of green films and metal foils is normally subjected to a sintering process.

In the most simple case, a passive electronic module is an electronic interconnect. It can be an inductance, a capacitor or a resistance (e.g. varistor as well). The components can occur on an individual basis or combined with one another and can be parts of an electronic circuit, in particular. A component is composed of a metal, a metalloid and/or a fixed electrolyte, for example.

The basic idea of the invention is to apply a multistage sintering process for producing a ceramic body. The method described in the introductory part of the specification is modified for preventing lateral shrinkage. In contrast to the traditional course of action, a ceramic layer is not removed after the sintering. Rather, a component is

integrated into each layer. This means that each ceramic layer is utilized for structuring a body having a more or less great number of electronic modules. On the basis of the selection of the ceramic materials (e.g. with different dielectric constants) it is thus possible to unite the greatest variety of passive components in a monolithic ceramic body. Furthermore, additional method steps for carrying away ceramic material can be foregone, and possibly the attaching of conductor structures or, respectively, pad structures on the surface of the body.

A ceramic green film is produced in a known way. The thickness of a green film ranges from 50 μm to 200 μm, for example. Glass ceramic having a low sintering temperature can be preferably used as ceramic material. The ceramic material, which is also referred to as glass-ceramic composite, contains aluminum oxide, boric oxide or alkaline earth oxide. The green film is tailored to the desired shape by cutting or punching. Said shape can directly be the lateral shape of the ceramic body.

The structuring of the green film is a part of the production of a ceramic green film as well. For example, at least one opening extending through the green film is generated in a green film for an electronic through-connection ("via-hole"). This is particularly possible in a simple way by punching. Another method for structuring a green film ~~films~~ ~~[sic]~~ such as a photolithography or the generation of an opening with the aid of laser radiation can also be applied.

In addition to the openings, which are necessary for the integration of a component, it is advantageous to generate additional holes in a green film, as a result of which the production of the ceramic body is significantly facilitated. It is particularly advantageous to generate a perforated structure in the multi-up of a green film, with which a plurality of sub-areas of the green film can be separated from one another. In this context, multi-up is a planar body having a plurality of identically structured sub-areas. The surface of a multi-up is 300 x 300 mm, for example. For example, n^2 identical sub-areas can be present on it (n x n - multi-up). A body can be simply

separated by breaking it out of the multi-up of the sintered green films with the aid of the perforated structure, which all green films stacked on top of one another have.

In a further method step, at least one metallization is attached to a surface of a green film. For this purpose, electrically conducting material, for example in the form of a conductor structure, is deposited onto a surface of the green film preferably in the silk screen printing process ~~process printing~~. A very fine conductor structure can be produced in this way. The width of an interconnect is 80 μm, for example, and the distance between interconnects is 80 μm as well.

In this production phase of a green film, the openings for the through-connections are filled with an electrically conducting material. The screen printing method is particularly advantageous here. Silk screen printing and screen printing are preferably carried out in the same device.

For example, a metal paste is processed for a conductor structure and an electrical through-connection. A resistor can be particularly simply integrated in that a co-sinterable resistance paste is processed.

As a result of the utilization of glass ceramic having a low sintering temperature, highly conductive silver or copper can be particularly processed. In a thick-film technology (e.g. silk screen printing technology), a sufficiently thick, highly conductive interconnects ~~[sic]~~ can thus be realized, which only has a very low line loss given a frequency of 1 GHz (skin depth = 3 μm) as well.

In the next method step, the ceramic green films are stacked on top of one another. Green films containing different ceramic material are thereby used

The ceramic material of a green film is selected according to the function that is to be integrated into the substrate with the aid of this green film. In addition, the sintering properties of the ceramic materials of the different green films are very important. At

least two materials must be used, which differ from one another at least by the temperature interval respectively necessary for the compacting. The first temperature interval and the temperature interval that is different from the first one are preferably separated. There is no temperature range in which the first ceramic material and the ceramic material that is different from the first one become compacted at the same time. As a result thereof, a multistage sintering process can be fashioned such that the shrinking of a first ceramic material has already been completed before the shrinkage of a second ceramic material starts.

In addition to the green films containing the two ceramic materials, further green films containing a ceramic material that is different from the first and second ceramic material can be very easily integrated. The sintering characteristic of this material is only required to have the compacting of the material completed after the at least two-stage sintering process.

It is to be generally observed that the selection of a ceramic material is tailored with regard to the utilized metal or, respectively, the utilized metals. For example, when highly conductive copper is integrated into the body, the compacting of the ceramic material must be completed at 950°C. The limit for silver is situated at 900°. Given the utilization of silver, it must also be guaranteed that the compacting of the ceramic material can occur under reducing conditions.

It is particularly important that the body produced from various materials is free of mechanical stress after the sintering and that it does not bend after the cooling. It is equally important that an undesired temperature-conditioned tension does not occur in the operation of the body. Therefore, it is advantageous when a plurality of ceramic materials exhibit an essentially same thermal coefficient of expansion in a specific temperature range. This means that mechanical stress as a result of a different thermal expansion of the different materials, at least in the discussed temperature ranges, is suppressed to an extent that the functionality of the ceramic body remains intact. The

thermal coefficient of expansion of a glass ceramic can be controlled by the type and quantity of a glass component. Thus, the thermal expansion behavior of the different ceramic materials can be matched to one another. It is particularly advantageous when the thermal coefficient of expansion of a ceramic material is situated at approximately 6 - 7 ppm/K given the working temperature of the body. Thus, a very advantageous adaptation to a semiconductor material such as silicon or gallium arsenide is present. An active electronic module (e.g. integrated circuit), which is attached to the surface of the ceramic body and which forms a functional unit (electrical component) together with the body, comprises such a semiconductor material, for example. An electrical component having the cited specification can be used in a broad temperature range. This is important with respect to an application of the electrical component in the automobile field, for example. In contrast thereto, a traditional polymeric substrate shows a clearly different thermal expansion behavior than a silicon-IC. A comparable polymeric substrate therefore is more limited regarding the applicability than a ceramic substrate.

The green films are preferably stacked such that an approximately symmetric film stack having an axis of symmetry parallel to the films results with respect to the different ceramic materials. As a result of this measure, a uniform shrinking is supported during the sintering process and the component tolerance is reduced.

Moreover, it can be advantageous to arrange a green film in the stack, which green film is only used for the shrinkage-free production of the body. The ceramic layer resulting from this green film can be electronically ineffective.

At least one layer composed of an electrode material is preferably arranged in the stack. This layer can be a structured metal foil, for example. It is possible to use a metal foil, since a lateral shrinkage does not occur in such a film. A metal foil has the advantage that it is of lesser electrical resistance (factor 2 - 3) compared to a metal paste. A metal foil is structured by punching and/or etching, for example.

a After the green films (and layers composed of electrode material) have been stacked and laminated to a composite, the common debinding of the composite occurs. This ensues in that the temperature is slowly increased up to 500°C, for example. The lamination ensues under an one-~~axle~~ Axis or isostatic pressure, for example.

Subsequent to the debinding, the composite is sintered in at least two steps. The compacting of a first ceramic material is initially carried forward at a lower temperature. A second ceramic material, which does not become compacted at this temperature, prevents lateral shrinkage, since the laminated films adhere to one another. A compacting only occurs perpendicular to the film planes. After the compacting of the first ceramic material has been completed, the temperature is increased to the sintering temperature of the second ceramic material. The first ceramic material, which has completed the compacting, prevents lateral shrinkage of the second ceramic material. It is thereby possible to decouple the different compacting curve of the different materials via the compacting in the direction of the thickness of a film. As a result of this decoupling, a purposeful adaptation of the sintering characteristic of the different ceramic materials is not necessary for a common sintering. The proportion of ingredients between sintering and non-sintering material plays a role for suppressing the lateral shrinkage. The ratio beneficially is less than or equal to four.

At least one further green film can be additionally processed, which comprises a further ceramic material, whereby the compacting occurs at a temperature interval differing from the first temperature interval and the second temperature interval. It can certainly be the case that this temperature interval overlaps with the first and/or second temperature interval. It is crucial that the stacking on top of one another occurs such that lateral shrinking of the composite is suppressed in each phase of the sintering by non-sintering ceramic layers.

The method is particularly suitable for firmly connecting the ceramic body to the carrier such as a metal body. For this purpose, the green films are preferably sintered directly onto a carrier in the multistage sintering process. The carrier can be a metal body acting as a cooling body, for example, during the operation of the ceramic body.

The stacking, laminating, debinding and/or sintering preferably occurs in a matrix having the outer dimensions of the body or multi-up, whereby a plurality of bodies are produced therefrom. The matrix consists of a material exhibiting excellent thermal conductivity and a low adhesion capability at the same time with respect to the ceramic body. The material of the matrix preferably comprises silicon carbide.

If a plurality of ceramic bodies are produced in the multi-up, the bodies are separated after the sintering. This can ensue by sawing. It is particularly simple to separate when a body is broken out of a multi-up along the aforementioned perforated structure. The breaking-out is also possible when a metal foil is processed in the multi-up. For this purpose, the metal foil is also provided with a perforated structure prior to the stacking. This perforated structure is ~~is [sic]~~ laterally offset vis-a-vis the perforated structure of a ceramic green film~~s~~ ~~[sic]~~, so that a metal web, which is situated between two holes of a metal foil, and a whole of a green film come to lie on top of one another. ~~[sic]~~ After the sintering, this metal web can be removed by etching, for example. If a silver metal foil is processed, a mixture of hydrogen peroxide and ammonia can be used for etching away a metal web. In this way, only ceramic webs remain in the body, which can be easily broken for the separation of a body. This course of action is not only suitable for the separation of a finished ceramic body. Since a present metal web of a metal foil is removed after the sintering, an operative integrated passive component possibly arises only then.

Prior or subsequent to the separation, it is possibly necessary to attach electrically conducting material to the surface of the ceramic body. As it has already been

described above, silk screen printing with an indicated material is appropriate therefor.

The invention covers a new ceramic body, which comprises a monolithic multilayer structure and which contains at least one passive electronic module, at least one layer composed of a ceramic material made of glass ceramic, which becomes compacted in a first temperature interval and at least one layer composed of a ceramic material made of glass ceramic, which becomes compacted at a temperature interval that is different from the first temperature interval.

A passive electronic module, for example, in the form of an inductance and a capacitor having a low value are situated in the ceramic body. In particular, a compact decoupling capacitor having a capacitive value between 30 pF and 3 nF can be realized. Compact line structures such as "strip-lines" or "tri-plates"of high quality for a resonator, coupler and band-pass filter also belong thereto. An inductance and a transformer of high inductive value are to be cited as examples as well. A varistor can also be contained in the ceramic body.

The ceramic body has at least one electrical through-connection, in particular. Such a through-connection can extend via a plurality of neighboring layers and can be a part of a complex integrated circuit. In particular, an electrical connecting point at the body surface, for example in the form of a soldering pad, is connected via a through-connection~~s~~ ~~[sic]~~ to a component in the inside of the body.

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In a special embodiment, the body comprises at least one layer composed of an electrode material. This layer is structured corresponding to the functions connected therewith and particularly is a part of a passive component. For example, a plate electrode for a capacitor can be realized in this way.

The body can be arranged on a metal body acting as a cooling body, for example. The body can thereby be glued or soldered onto the cooling body. It is particularly advantageous when the body is connected to the cooling body in a monolithic fashion (for example by silk screen printing).

The material of a passive electronic module, of a layer composed of electrode material and/or of a metal body comprises at least a material, which is selected from the group gold, copper, molybdenum, palladium, platinum, silver and/or ~~wolfram~~ tungsten. It is particularly advantageous when the material consists of highly conductive gold, silver or copper. Alloys of the metals such as silver/palladium are conceivable as well. Moreover, a semiconductor material and resistance material can be integrated.

Glass ceramic having a low sintering temperature is particularly suitable as ceramic material. The glass ceramic of a layer can be present in the form of a two-phase glass matrix (glass phase and ceramic) or in the form of a crystalline glass ceramic matrix.

The ceramic material of a layer depends on the function, which is integrated with this layer in the ceramic body. In order to realize a simple electrical feeder~~s~~ ~~[sic]~~ through a layer, this layer preferably consists of a material having an optimally low dielectric constant ($6 \leq \varepsilon_r \leq 8$). The signal propagation time through the feeder thereby is reduced or, respectively, a signal delay is prevented. On the basis of such a ceramic material, a capacitor of low capacitance (down to 10 pF) and with an inductance (down to 10nH) can be integrated. Such a component ~~are [sic]~~ is suitable up to frequencies of a few GHz due to its compact structure. ~~[sic]~~

An average dielectric constant ($25 \leq \varepsilon_r \leq 60$) is advantageous for such layers, by means of which a microwave resonator structure or filter structure is realized (for example $\lambda/4$-resonator). On the other hand, a dielectric having a relatively high dielectric constant ($\varepsilon r > 500$) is advantageous for a decoupling capacitor.

A ceramic body is particularly characterized by a low lateral tolerance when a first stack of layers with a first layer sequence and a second stack of layers with a layer sequence that is reversed with respect to the first layer sequence are arranged on top of one another. A body that is approximately symmetric regarding the ceramic layers results therefrom, this body having a symmetry plane parallel to the layers. An additional layer can be arranged between the two layer stack ~~[sic]~~.

Due to the low component tolerance of a presented ceramic body and the plurality of electronic modules, which can be integrated into the volume of the body, the body is particularly appropriate as substrate of an optimally small, complex electronic module (e.g. of a high-frequency module).

In total, there are the following striking advantages as a result of the invention concerning the ceramic body having a monolithic multilayer structure, and concerning the method for producing the body:

- As a result of a multistage sintering process, it is possible to suppress the lateral shrinking of the composite of the ceramic green films. A very low component tolerance of up to 0.1 % down ~~[sic]~~ results therefrom.
- A thermomechanical optimal layer structure composed of ceramic having a low sintering temperature and a high sintering temperature can be obtained upon consideration of the electrical and circuit-oriented criteria.
- As a result of the reduction of necessary soldering contacts between the passive components of a circuit and the hermetic protection of the inner circuit, a high robustness and product reliability can be obtained.
- The method is particularly suitable for producing a ceramic body in the multi-up. Relatively simple and extremely complex bodies therefore can be cost-efficiently produced.
- Besides, a high environmental compatibility results due to a simple reusability of a ceramic circuit carrier.

On the basis of a simple exemplary embodiment and the corresponding Figures, a ceramic body, which has a monolithic multilayer structure and at least one passive electronic module, is presented, as well as a method for its production. The Figures are schematic and are not made to scale with respect to the cited articles.

a BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a ceramic body in cross-section.

Figure 2 shows the dependency of the shrinking of the ceramic materials on the temperature; the ceramic body is composed of said ceramic materials.

Figure 3 shows the temperature program with which the ceramic body is sintered subsequent to the debinding.

Figure 4 shows the effect of the temperature increase on the ceramic body.

~~Figure 5~~, proceeding ~~from the production of a green film,~~ shows ~~the crucial method steps for pro~~ducing the ceramic body.

Figure 6 shows a ceramic green film multi-up having a perforated structure.

Figure 7 shows a section of a sintered multi-up, whereby a ceramic layer and a layer composed of electrode material are arranged on top of one another, prior to an etching process.

Figure 8 shows a section of a sintered multi-up, whereby a ceramic layer and a layer composed of electrode material are arranged on top of one another, subsequent to an etching process.

a DESCRIPTION OF THE PREFERRED EMBODIMENTS

Subject matter is a multilayer ceramic microwave module 1 having a monolithic multilayer structure. Each ceramic layer has a thickness of approximately μm. The

two inner layers 11 and 12 are composed of a glass ceramic101 with a dielectric constant of approximately 80. It comprises a material of the composition $Ba_{6-3x}Me_{8+2x}Ti_{18}O_{54}$ $(0 \leq x \leq 1)$. Me stands for the rare earths Sm, Nd and La. The compacting of the ceramic material of these layers occurs between approximately 870°C and 970°C. The two outer ceramic layers 13 and 14 comprise a glass ceramic having a dielectric constant of approximately 6. This material is based on a barium-aluminum-silicate glass and becomes compacted between 720 and 850°C. Figure 2 shows the shrinking of the ceramic materials 101 and 102 in the form of a relative change in length in a direction $\Delta L/L$ as function of the temperature.

The body 1 is composed of two layer stacks 111 and 112. The layer stack 111 has a layer sequence in the direction 113. The layer stack 112 has the same layer sequence in opposite direction 114. A body that is approximately symmetric with respect to the two ceramic materials 101 and 102 is present, this body having a symmetry plane, which, as it were, is situated between the layer 11 and 12 and which is parallel to these layers.

Passive electronic modules 15 - 20 are situated on the top surface and bottom surface, as well as in the volume of the body. The material of the component parts comprises copper. In addition to an interconnect 16, soldering pads 17 are attached to the top surface of the body, whereby a SMD component and an IC can be connected to the body with the aid of said soldering pads 17. In addition to an interconnect 16, soldering pads 18 for soldering the body onto a printed circuit board are situated on the bottom surface.

Plate electrodes for capacitors and internal conductor structures for tri-plate resonators are situated between the inner layers. These component parts are formed with the aid of a structured layer composed of electrode material 20. The counter electrodes with respect to the capacitors and resonators are situated between the inner and outer layers. In addition, the body 1 has an electrical through-connection 19.

The previously described multilayer ceramic microwave module 1 is produced in the multi-up. Figure 5 discloses the crucial method steps.

A ceramic green film containing an organic binder is initially produced (process 501). The ceramic base material composed of glass ceramic having the desired composition is produced in the mixed-oxide method or sol-gel method, for example. Together with the organic binder and a solvent, a slurry is produced from the base material, whereby the green film is pulled or cast from said slurry. The green films have a layer thickness of 150 μm after the drying.

In the following method step 502, holes are generated in the green film by punching. This means for an n x n multi-up that n x n identical hole combinations are generated in the green film. Depending on the functionality of the ceramic layer resulting therefrom, a hole combination, for example, contains openings 63 (see Figure 6) with which through-connections 19 can be generated. The hole combinations are separated from one another as a result of the perforated structure 62 (Figure 6).

In the following step 503, an electrically conducting material is printed onto the green film 61 in the silk screen process printing. A cupreous paste is utilized for this purpose. Interconnects of 80 μm and plate electrodes are deposited.

As far as openings 63 are present for an electrical through-connection, they are filled with electrically conducting material in the screen printing method. Screen printing and silk screen process printing are carried out by means of the same device.

In the following phase 504, the green films are stacked in the multi-up such that the above-described stack sequence results. A structured copper metal foil 20 is arranged between the layer 12 and 13. The stacked green films, under an one-~~axle~~ axis pressure, are laminated to a multi-up of a composite 51. The composite 51 is rid of the binder in that the temperature is slowly increased by 2K/min, for example (Figure 5, 505).

Subsequent to the debinding or removing the binder, the sintering ensues in two steps (Figure 3 and 4). The temperature is initially increased up to 820°C (506). The ceramic material 102 of the outer layers 13 and 14 of the composite becomes compacted at this temperature. The temperature is kept until the compacting of this ceramic material is completed.

In the second step 507, the temperature is increased up to 950°C and is kept until the ceramic material 101 of the inner layers 11 and 12 is compacted.

These method steps are carried out in a matrix, which has the dimensions of the multi-ups of the green films. The matrix is composed of silicon carbide.

Subsequent to the cooling, the microwave modules can be separated by breaking apart the multi-up along the perforated structure 62 and thus can be used for the further processing.

A correspondingly ~~a [sic]~~ structured metal foil 72 is used during the production of the ceramic body. The structuring or, respectively, generating of openings ensues by punching. In addition to the openings on which the functionalities to be integrated are based, a perforated structure 73 facilitating the separation of a finished ceramic body is generated in the metal foil 72. The perforated structure 73 is laterally offset vis-a-vis the perforated structure 75 of a ceramic green film 74, so that a metal web 76, which is situated between two holes 77 and 78 of a metal foil 72, and a hole 79 of a green film 74 come to lie on top of one another given the stacking of the films. Figure 7 shows a section of a sintered multi-up 71 deriving from the stacked metal foil 72 and green film 74. The Figure shows the multi-up prior to the etching process. The perforated structure 73 is represented in dots where the metal foil (layer composed of electrode material) 72 cannot be seen.

In order to separate the individual bodies (microwave modules) from a so sintered multi-up 71, the remaining metal webs 76 of the metal foil 72 need only be removed.

This is possible by etching with the aid of a strong oxidant attacking copper. A multi-up 81 that only comprises ceramic webs arises in this way. The individual bodies can be separated again by breaking. Figure 8 shows the multi-up 81 acquired from the multi-up 71 by means of an etching process.

A microwave module can also be further processed prior to the separation in the multi-up, whereby said further processing contains the production of conductor structures and soldering pads and, in the further process, the attachment of SMD component parts and IC's in flip-chip technology to the surface of the module, for example.